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Blood-sucking Flies, Ticks, etc., and How to Collect Them.

By E. E. AUSTEN.

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Blood-sucking Flies, Ticks, etc., and How to Collect Them.

In view of the possible importance of Blood-sucking Arthropoda, other than Mosquitoes and Tsetse-flies,* in the dissemination of diseases due to micro-organisms, in addition to the knowledge that certain maladies are actually carried by Ticks, it is proposed to publish a series of monographs in which these creatures and their bionomics shall be fully and accurately described and illustrated. Since, however, the material already available in the collection of the British Museum is insufficient for this purpose, *carefully collected and properly labelled* specimens of Blood-sucking Flies, Ticks, etc., are now urgently required from all parts of the world. With a view to assist medical men and others who may be willing to help in the collection of specimens, the following pages contain—(i) Notes on Blood-sucking Flies, other than Mosquitoes; (ii) Directions as to the way in which these insects should be collected and forwarded to England; (iii) Notes on collecting Fleas, Bugs, and Ticks.

PART I.

Notes on Blood-sucking Flies, other than Mosquitoes.

How to Distinguish Flies (Diptera) from Other Insects.

The presence of a pair of little knobbed organs (the halteres or balancers) behind the wings, and the absence of caudal filaments distinguish Flies (Diptera) from the winged males of Coccidæ (Scale-insects). From all other insects Diptera may be distinguished by the fact that they possess *only one pair of wings*.† Thus, besides

* "A Monograph of the Culicidæ or Mosquitoes" (3 Vols. and 1 Vol. of plates; 1901, 1903), by F. V. Theobald, and "A Monograph of the Tsetse-flies" (1903), by E. E. Austen, have already been published by the Trustees of the British Museum.

† For present purposes it is unnecessary to take into account certain aberrant *wingless* forms, which in the majority of cases do not suck blood. In some of these forms even the halteres are absent.

ordinary flies, such as Blue-bottles and House-flies (*Muscidæ*), the Order also includes Midges (*Chironomidæ*), Gnats or Mosquitoes (*Culicidæ*), Daddy-long-legs (*Tipulidæ*), Horse-flies (*Tabanidæ*), etc.

Blood-sucking Flies: Their Appearance, Life-history, and Habits.

With the exception of the Gnats or Mosquitoes (*Culicidæ*), blood-sucking species of Diptera occur, so far as at present known, only in the following families:—Chironomidæ, Blepharoceridæ, Simulidæ, Psychodidæ, Tabanidæ, Leptidæ, Muscidæ, and Hippoboscidæ. The enormous majority of Blood-sucking Diptera belong to the family Tabanidæ (Horse-flies or Dun-flies, Clegs, Serut-flies), in which the blood-sucking habit is universal in the female sex; in the other families enumerated, if we exclude the Simulidæ and Hippoboscidæ, the habit is exceptional, and the species concerned are comparatively few. As a rule, the blood-sucking habit is confined to the females, and it may be noted as a somewhat remarkable fact, that a large proportion of the species have aquatic larvæ.

Chironomidæ (Midges):—genus *Ceratopogon*.

The blood-sucking species at present known are confined to the genus *Ceratopogon*, which is universally distributed, and at the present time comprises some hundred and eleven described species. The blood-sucking habit, however, is exceptional in the genus, and is limited to the female sex.

Appearance.—Extremely small flies, as a rule (in the case of species known to suck blood), not exceeding $1\frac{1}{2}$ or 2 mm. in length, though the males are usually somewhat larger than the females; generally blackish or dark grayish-brown in colour, but the abdomen of the female, after feeding, often rosy, owing to the contained blood. The wings when at rest are carried flat, closed one over the other like the blades of a pair of scissors; in many species they are hairy, and they are often speckled with grayish-brown blotches. The sexes can be distinguished owing to the possession by the males of tufted antennæ and a more elongate shape.

Life-history.—As a general rule, the larvæ of naked-winged species of *Ceratopogon* are aquatic, those of hairy-winged species terrestrial. The eggs of aquatic species are laid in floating algæ, in star-shaped clusters containing from one hundred to one hundred and fifty. The larvæ of these species are whitish worm-like creatures, with long narrow heads, and live in the masses of Confervæ floating on the surface of stagnant pools and ditches. They are without prolegs on the prothoracic segment, and progress with a serpentine motion. The pupa, which is shorter than the larva, with a conspicuous pair of respiratory horns on the thorax, is brownish in colour, possesses

little power of movement, and remains at the surface of the water. The larvæ of the hairy-winged species live under the damp bark of dead trees, in weeping spots on tree-trunks, and in decaying vegetable matter generally, such as manure, rotting fungi, etc. These terrestrial larvæ are usually shorter than the aquatic ones, and do not move in serpentine fashion, but are provided with a cleft proleg on the underside of the prothoracic segment, while the head and body segments also bear peculiar lancet-shaped hairs and spines. Serpentiform larvæ, which have produced midges with hairy wings, have, however, been found in the sap saturating diseased bark on tree-trunks.

Habits of the perfect insects.—In spite of their small size, the females of certain species of *Ceratopogon* are among the most irritating and bloodthirsty of insects, both in the tropics and also in temperate regions. Writing of a species found in Uganda (see fig. 1), a recent observer * says: "It is very common in many places, usually near habitations. This minute fly can pass through the finest mosquito netting; muslin I have not tried. It bites terribly, leaving an irritating wheal, which itches for days. It makes a sharp, short, peevish buzz when settling, fully as loud as a mosquito. It attacks the wrists chiefly, but is able to pass beneath a sheet, and bite the ankles and feet. Many were frequently found full of blood on turning down the bed-clothes. I have met with a similar fly, with the same habits, at Ahmednuggar (Bombay Presidency), India." It is probable that, in some places at any rate, midges torment domestic animals in addition to human beings.

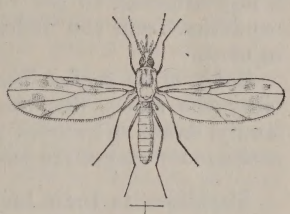

FIG. 1.—*Ceratopogon sp.* ♀. Uganda. (× 12.)

Blepharoceridæ:—genus *Curupira*.

No specimens of this genus have actually been observed sucking blood, and its inclusion among blood-sucking Diptera is due to the statement by Fritz Müller that a certain number of the females of the only species at present known, *Curupira* (*Paltostoma*) *torrentium*, F. Müll., have mouth-parts of the blood-sucking type, while other females agree with the males in possessing mouth-parts adapted for feeding upon the nectar of flowers. Müller's conclusion that the two kinds of female both belong to the same species, which therefore presents a striking instance of dimorphism in the female sex, requires confirmation, and it may even ultimately be found that the supposed blood-sucking females merely prey upon other

* Dr. Cuthbert Christy, "Reports of the Sleeping Sickness Commission," No. III., pp. 39–40 (London: Harrison & Sons, November, 1903).

insects and do not feed upon mammalian blood. *Curupira torrentium* occurs in Brazil.

Appearance.—Gnat-like flies, varying from about 4 to 7 mm. in length, with strongly iridescent wings, which are marked with a secondary network of crease-like lines in addition to the veins.

Life-history.—The larvæ are curious wood-louse-like creatures, living in swiftly flowing streams and torrents, in which they attach themselves to bare rocks and stones by means of a row of median ventral suckers. The ordinary segmentation is not visible, but the sides of the body are scolloped out into a series of prominent lobes. The pupa, which bears a pair of respiratory horns in front, is strongly convex above and flattened beneath; it is found with the larvæ, so firmly attached to the rocks, apparently by means of a chitinous exudation from the underside, that it is not easy to remove it uninjured.

Habits of the perfect insects.—At present unknown. In all probability the males, like those of European species belonging to this family, dance in swarms in the air over the streams in which the preliminary stages are passed.

Simulidæ (in India known as *Sand-flies*; in the United States as *Black flies*, *Buffalo-gnats*, and *Turkey-gnats*).

This family consists of the single genus *Simulium*, which is universally distributed, and of which some sixty-six species, difficult to

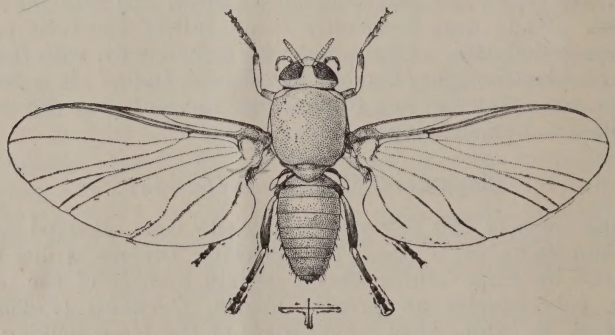

FIG. 2.—*Simulium sp.* ♀. Vernon, B. Columbia. (× 12.)

distinguish one from another, have been described up to the present time. The females of some of these flies, which are among the most dreaded of all blood-sucking Diptera, sometimes occur in enormous swarms, and by their attacks upon horses, mules, and cattle, especially in certain parts of the United States, occasion great losses among these animals, besides frequently molesting human beings. In the

district of South Hungary called the Banat the Columbacz Midge (*Simulium columbaczense*, Schönb.) has been notorious for more than a hundred years, owing to the destruction caused by it among cattle.

Appearance.—Small black or grayish flies, varying in length from $1\frac{1}{2}$ to 4 mm. according to the species, with a conspicuously humped thorax, short straight antennæ, delicate iridescent wings, stout legs, and with the proboscis not projecting. In the male the eyes appear to occupy the whole of the head, and meet in the middle line above; in the female they are smaller and separate.

Life-history.—The preliminary stages are passed in running water. The eggs are deposited in a compact layer or gelatinous mass on stones or plants close to the water's edge. The larval stage lasts for about four weeks in the summer in temperate climates, though longer in cold weather, and the winter is passed in this stage. According to Johannsen, the full-grown larva of even the largest American species does not exceed 15 mm. in length. In shape the larva is somewhat cylindrical, broadest posteriorly, where it is attached by means of a sucker to a stone, the stem of a water-plant, a dead leaf, or other object. The larva is able to shift its position by crawling in a looping fashion, but usually remains in a more or less erect position. It feeds on algæ, diatoms, and parts of phanerogamous plants, which are brought to the mouth by means of the currents set up by two broad fan-like organs situated upon the head. In colour the larva varies according to the species, and perhaps also to some extent in accordance with its food, from deep shining black to yellow or dark green. When mature, the larva spins a silken cocoon, within which it pupates, and in which the pupa remains motionless, breathing by means of a pair of branched respiratory filaments, which project from behind the head. The pupal stage lasts for about a week, and the perfect insect, making its escape through a rent in the back of the thorax, ascends to the surface in a bubble of air, and makes its way to some support on which it rests until its tissues are sufficiently hardened to enable it to fly.

Habits of the perfect insects.—The males, which are incapable of sucking blood, are fond of dancing in the sun in swarms high in the air; the females usually remain at a lower level. In attacking horses and cattle they show a great fondness for the inside of the ears; but they also devote themselves to any part of the body where the skin is thin and not well protected by hair: in the case of human beings they frequently attack the corners of the eyes. In Uganda, according to Dr. Christy,* a species of *Simulium* occurs in a "belt" about 12 or 15 miles in length, by 3 or 4 miles in width, on the right bank of the Nile. "In this area the flies swarm at certain seasons in millions," and become such a pest that the natives

* *Loc. cit.*, p. 40.

are forced to leave their plantations. "The bite of this small fly," adds Dr. Christy, "is a very severe one, and causes a wheal which itches intolerably, and is marked by a large drop of blood."

Psychodidæ, genus *Phlebotomus* (in the Sudan and Ceylon called *Sand-flies*).

In this family the blood-sucking habit is altogether exceptional, being confined to the genus *Phlebotomus*,* of which only three or four species, which occur in Southern Europe, the Mediterranean Sub-Region, the Egyptian Sudan, and Ceylon, are at present known. It is probable that the females alone suck blood.

Appearance.—Small yellowish-brown flies from $1\frac{1}{3}$ to 2 mm. in length, with the body and wings densely clothed with long hair. Antennæ, palpi, and legs long; proboscis straight, projecting vertically beneath the head. Abdomen of the female roseate when full of blood. Care must be taken not to confuse with *Phlebotomus* the harmless species belonging to other genera of Psychodidæ, all of which are small, densely hairy, moth-like flies, but with the proboscis scarcely, if at all, visible.

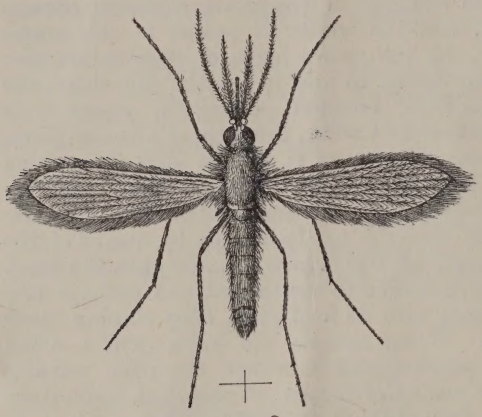

FIG. 3.— *Phlebotomus sp.* ♀. Kassala, Sudan. (× 12.)

Life-history.—Unknown. The preliminary stages, however, are doubtless passed in water or in liquid filth, as in cesspools.

Habits of the perfect insects.—According to Rondani, in Northern Italy *Phlebotomus papatasii* is found on the higher slopes of the hills as well as in the marshy plains. As evening approaches, the males very often, the females more rarely, are found on windows. *Phlebotomus minutus* appears to be more confined to the low ground near streams, and to enter houses less frequently.

Tabanidæ (*Horse-flies*: in Great Britain certain species are also known as *Dun-flies*, *Clegs*, and *Stouts*; sometimes erroneously called

* Since this was written I have been informed by the Rev. A. E. Eaton that in England he has observed blood in the abdomen of *Sycorax silacea*, Hal., and has made a similar observation in Algeria in the case of an undescribed species of the same genus. Of course the blood may not have been human.—E. E. A.

Gad-flies: on the Upper Nile termed *Serut-flies*, and in West Africa *Mangrove-flies*—a designation, however, which also includes Tsetse-flies).

As already stated, the enormous majority of blood-sucking Diptera

FIG. 4.—*Chrysops fixissimus*, Walker, ♀. Singapore, Borneo. (× 3.)

belong to this family, in which the blood-sucking habit is universal in the female sex. The Tabanidæ are world-wide in their distribution, and are among the largest of all families of Diptera, the total number of species described at the end of the year 1902 being no less than 1,540. The majority of the species that have hitherto

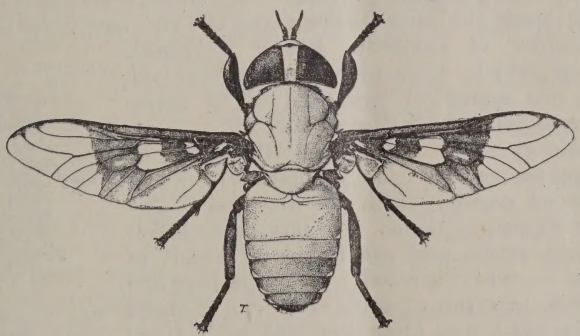

FIG. 5.—*Tabanus latipes*, Macq. ♀. East Africa Protectorate. (× 2.)

attracted attention by reason of their bloodthirsty habits belong to one or other of the four principal genera, *Tabanus*, *Pangonia*, *Hæmatopota*, and *Chrysops*. Of these *Tabanus* includes 905, *Pangonia* 246, *Chrysops* 146, and *Hæmatopota* 48 species. It is possible that more thorough knowledge may enable some of these genera to

be broken up, although the details of structure within each genus are remarkably uniform.

Appearance.—Bulky-bodied flies, ranging in length from about 6 mm. in the case of a small species of *Chrysops* (fig. 4), to more than an inch in that of the largest species of *Tabanus* (fig. 5). The head is large, convex in front, concave or flattened behind, in the male almost wholly composed of the eyes, which meet together above in that sex, but are separated in the female. In life the eyes usually exhibit golden-green or purple markings. The antennæ project conspicuously in front of the head, as does also the proboscis in many species of *Pangonia* (fig. 6), in which genus the latter organ is sometimes enormously elongated. In other genera the proboscis is short, and protrudes vertically beneath the head, with the piercing mouth-parts enclosed in a fleshy lower lip. In coloration the majority of Tabanidæ are somewhat sombre, some shade of brown or black being the most frequent hue, the abdomen, however, often being lighter or exhibiting lighter markings. The wings, which, when at rest, diverge at the tips or are somewhat tectiform, are in many species conspicuously banded or blotched.

FIG. 6.—*Pangonia magrettii*, Bezzi. ♀. Kassala, Sudan. (× 2.)

Life-history.—The spindle-shaped brown or black eggs are deposited closely packed in spherical or flattened masses, which are attached to the leaves and stems of plants. The larvæ are whitish soft-bodied grubs, and are found in water, in earth, or in decaying wood. In shape they are cylindrical, tapering at each end, with a small retractile head, and often encircled with rings of retractile fleshy protuberances, which, however, may be confined to the ventral side. These larvæ are carnivorous, preying upon beetle larvæ, snails, worms, etc. The pupa, which is not unlike that of a Lepidopterous insect, remains stationary in the earth or water.

FIG. 7.—*Hæmatopota sp.*, from Zululand, in resting attitude, showing the position of the wings (× 2). The wing markings are omitted.

Habits of the perfect insects.—The males haunt flowers or herbage,

but occasionally hover in the air. The blood-sucking females are persistent tormentors of human beings and domestic animals; horses, cattle, and elephants often streaming with blood in consequence of their attacks. In the Egyptian Sudan Sir Samuel Baker speaks of herds of game as retreating before the attacks of Serut-flies. The species of *Hæmatopota* and *Chrysops*, and the smaller species of *Tabanus* are remarkable for the quietness with which they alight on their victims, the sharp prick of the bite being often the first intimation of the presence of the fly. The larger species of *Tabanus* betray their approach by their loud hum.

Leptidæ (no English names known).

The Leptidæ are a small but widely distributed family of slenderly-built flies of moderate size. Their inclusion among blood-sucking forms is due to individuals of four different species having been observed in a small number of instances to suck human blood; but since the Leptidæ normally prey upon other insects the blood-sucking habit is certainly exceptional and perhaps to be ascribed to individual aberration. The species in the case of which the habit has been recorded are an undescribed *Symphoromyia*, the female of which, according to Baron Osten Sacken, who observed it near Webber Lake, California, in the month of July, bites quite painfully "and draws blood like a *Tabanus*"; the common European *Leptis scolopacea*, Linn. (of which both sexes have been stated to bite) and *L. strigosa*, Mg.; and *Trichopalpus obscurus*, Phil., a species with an elongated proboscis, common in the Province of Valdivia, Chile, in December and January, and said to be a greedy blood-sucker. The observations with regard to the two species of *Leptis* were made in France.

Appearance.—Narrow-bodied flies, from 6 mm. to 13 mm. in length, with long legs and with the abdomen usually tapering towards the tip. The eyes meet together in the males above the small antennæ, but are separate in the females. The proboscis is usually short and fleshy, occasionally elongated; the venation of the wings resembles that of the Tabanidæ. As a rule some shade of brown or yellowish brown forms the prevailing colour, and the wings are frequently blotched with brown. When at rest the wings are carried flat or nearly so, diverging widely at the tips.

Life-history.—The oviposition of the alleged blood-sucking species has not been observed. According to Beling, the larvæ of *Leptis*, which are shining white or yellowish in colour, with a small brown head, and four papillæ arranged in the form of a square on the anal segment, subsist chiefly upon earthy and decaying vegetable matter, and are found for the most part in woods, beneath the carpet of leaves or pine needles, as well as in decaying tree-stumps, etc. The same author states that the larvæ of *Leptis* may be

distinguished at the first glance from other similar larvæ, such as those of *Hæmatopota*, by certain characteristic markings on the upper side of the first two body segments, by the structure of the anal segment, and especially by their great mobility. The larva of *Symphoromyia crassicornis*, Pz., a European species, was found by Beling under turf at the edge of a beech-wood. It is described as measuring 12 mm. in length, dirty white in colour, tapering somewhat towards both extremities, with a small brown head.

Habits of the perfect insects.—The flies of the sub-family *Leptinæ*, which includes the genera *Leptis* and *Symphoromyia*, are somewhat sluggish, and are fond of resting motionless and head downwards upon the trunks of trees in shady places. Their flight is short and noiseless.

Muscidæ (*Tsetse-flies*, and their allies).

In this family the blood-sucking habit is highly exceptional, and is confined to a very few genera and species, all of which in appearance present a general resemblance to the Common House-fly. In cases in which the blood-sucking habit occurs, it appears to be common to both sexes. The following are the blood-sucking genera of Muscidæ hitherto described: *Stomoxys* (with eight species; this genus is universally distributed, and it is probable that several additional species have yet to be described); *Lyperosia* (with two species, one of which occurs in Europe and North America, the other in Somaliland; two additional species, probably distinct and as yet undescribed, are found in Sokotra and Ceylon); *Hæmatobia* (with three species, two European, the third found in Java); *Beccarimyia* (with a single species, described from the neighbourhood of Massowah); and *Glossina*, or Tsetse-flies (eight species, restricted to Africa). In addition to the foregoing, representatives of two species for which a new genus will probably have to be created have recently been obtained in West Africa and India.

FIG. 8. *Stomoxys sp.*, from Natal, in resting attitude, showing the position of the wings (× 1¼.)

N.B.—In view of the near relationship between *Stomoxys* and *Glossina* (Tsetse-flies), it is desirable that special attention should be paid to the former in order to discover whether the species of this genus are capable of conveying any species of *Trypanosoma*.*

Appearance.—As stated above, the blood-sucking Muscidæ all present a general resemblance to the Common House-fly, which however, in the case of Tsetse-flies, is obscured by the fact that the wings in the resting position (fig. 10),

* A species of *Stomoxys*, abundant in Mauritius during the hot season, has just (Nov. 1905) been announced to be the "almost certain" disseminator of Surra in that island. See Lieut.-Col. Manders, "Journal of the Royal Army Medical Corps," Nov. 1905, pp. 623–626.

instead of diverging at an angle, are closed one over the other like the blades of a pair of scissors. With the exception of the largest species of *Glossina*, these flies are all of small or moderate size; and even the largest Tsetse-flies do not exceed 12 mm. (about half an inch) in length, exclusive of proboscis and closed wings. The length of an average specimen of *Lyperosia* is from 3 to 4 mm., that of a similar specimen of *Stomoxys* about $6\frac{1}{2}$ mm. The coloration of the flies of this group is some shade of gray, brown, or yellowish brown, sometimes with darker markings; in certain of the species of Tsetse-flies, although not in all, the abdomen is conspicuously banded. The wings of blood-sucking Muscidæ are uniformly hyaline or brownish, never blotched or mottled. The sexes are usually very similar, but can generally be distinguished by the eyes being closer together in the males. Lastly, it is to be noted that in all forms there is a hard chitinous proboscis ensheathed in the palpi in the case of Tsetse-flies, which in its normal position, when not in use, projects horizontally beneath and in front of the head.

Life-history.—With the exception of *Glossina* the species of this group breed in dung, depositing eggs from which are developed white maggots of the type of those of the Common European Blow-fly. According to Riley and Howard, *Lyperosia irritans*, L. (*Hæmatobia serrata*, Rob.-Desv.), oviposits on fresh cow-dung, and its eggs are irregularly oval in shape flattened on one side, and from 1·25 to 1·37 mm in length, by 0·34 to 0·41 mm. in width. The newly hatched larvæ descend into the dung, and eventually when full-grown attain a length of 7 mm. Pupation takes place in the ground beneath, at a depth of from half to three-quarters of an inch. The puparium is of the normal Muscid type, dark brown in colour, barrel-shaped, and from 4 to 4·5 mm. in length, by 2 to 2·5 mm. in width. *Stomoxys calcitrans*, L., a species that is abundant throughout Europe and North America, breeds in horse-droppings, and its larvæ are very similar to those of the Common House-fly, which also breeds in horse-dung. The life-history of Tsetse-flies is of an abnormal type, the female producing a single larva at a time, which is retained and nourished within the oviduct of the mother until full-grown, and on being extruded at once crawls away and turns into a pupa so soon as it finds a suitable hiding-place. The pupa is dark brown, with a pair of prominent granular protuberances at the posterior extremity.

Fig. 9.—*Lyperosia sp.* ♂. Sokotra (× 3).

Habits of the perfect insects.—Some of the species of this group, especially those of *Stomoxys* and *Glossina*, attack man as well as domestic animals, and it is possible that in the case of *Glossina palpalis*, in certain parts of Africa, at any rate, such as Uganda,

human blood forms the chief food; other species of Tsetse-flies appear to subsist normally on the blood of big game.* The species of *Lyperosia* attack horses, cattle, and camels. In the United States *Lyperosia irritans* (*Hæmatobia serrata*) is known as the "Horn-fly" from its habit of clustering in masses about the base and on the concave side of the horns of cattle. According to Riley and Howard, it reduces the condition of stock to a considerable extent, but statements as to the death of animals from its attacks are unsubstantiated. When feeding, the fly is found on the back, flanks, legs, and under the thighs. In Europe and North America *Stomoxys calcitrans* is often found in houses.

FIG. 10. — *Glossina longipennis*, Corti, from Somaliland, in resting attitude, showing the position of the wings (× 1½).

Hippoboscidæ.

This family, which is distributed throughout the world, includes a number of small genera, the species of which are all parasitic on mammals and birds. From the point of view of possible dissemination of disease, however, it is unnecessary to consider here the bird-parasites belonging to the genera *Olfersia*, *Ornithomyia*, etc.† The mammal-parasites are comprised in the genera *Hippobosca*, *Allobosca*, *Ortholfersia*, *Lipoptena*, and *Melophagus*. The genus *Hippobosca* is probably represented throughout the world, and, with one exception,‡ its seven or eight species are parasitic on horses, donkeys, camels, cattle, or dogs. It is probable that certain species have been introduced with horses into new localities. At Pretoria Dr. Theiler has succeeded experimentally in inoculating cattle with *Trypanosoma theileri* by means of *Hippobosca rufipes*, v. Olfers (fig. 11). *Allobosca*, comprising the single species *A. crassipes*, Speiser, has only rudimentary wings, and is parasitic upon lemurs in Madagascar. *Ortholfersia*, of which

FIG. 11. — *Hippobosca rufipes*, v. Olfers. Griqualand West, S. Africa (× 2).

* For further information on the habits, etc., of Tsetse-flies, see "A Monograph of the Tsetse-flies," by E. E. Austen (London, 1903: published by the Trustees of the British Museum).

† Similarly, the bat-parasites belonging to the families Nycteribidæ and Streblidæ, which with the Braulidæ (bee-parasites) and the Hippoboscidæ make up the group of Diptera known as the Pupipara, may also be disregarded. It should be noted, however, that under exceptional circumstances human beings may be attacked by parasitic blood-sucking insects which are normally found on quite other hosts.

‡ *Hippobosca struthionis*, Janson, which is said to be found on ostriches in Cape Colony.

two species have been described, is found on kangaroos and wallabies in Australia, Tasmania, and New Zealand. The four or five known species of *Lipoptena* are deer- and goat-parasites occurring in Europe, North and Central America, Japan, Malacca, and Sinai. Recently the European *Lipoptena cervi*, L., has been met with in the Transvaal, and it is possible that it was accidentally introduced with remounts during the Boer War. The single species of *Melophagus* (*M. ovinus*, L.) is a parasite of sheep in Europe and North America.

Appearance.—Broad, flat-bodied, horny flies, with long wings, except in the case of *Allobosca*, and of *Melophagus*, which is entirely apterous, and very dissimilar in appearance to an ordinary fly; in the other forms the wings in the resting position lie flat over the body, closed one over the other like the blades of a pair of scissors (fig. 11). The female *Lipoptena* almost invariably sheds her wings on reaching a suitable host, and the male frequently does the same. In length these insects range from about 3 mm. in the case of a small *Lipoptena*, to 12 mm. or nearly half an inch in that of a female *Hippobosca camelina*. The general coloration is a reddish- or yellowish-brown, with the thorax mottled with yellow in the case of *Hippobosca*. The legs in all species are powerfully developed, and the claws have a secondary process on the underside to assist the insect in clinging to the hair of the host. The eyes are widely separated in both sexes, and the proboscis consists of a pair of downwardly projecting lobes, between which a slender inner tube can be protruded from the head.

Life-history.—The mode of reproduction of these flies may be described as a further development of the process seen in the Tsetse-flies. In the case of the genera now under consideration, the larva is retained within the oviduct of the mother, as in *Glossina*, but on extrusion it is incapable of movement, shows little or no trace of segmentation, and its integument simply becomes chitinised and darkened to form the pupal envelope. The larva of *Hippobosca* on extrusion is a white ovoid or globular body, with a black cap at one pole, which speedily becomes almost obliterated by the general chitinisation of the integument.

Habits of the perfect insects.—The winged members of this group as a rule fly but little, and only for the purpose of moving from one host to another, or from one part of the body of a host to another on being disturbed. When using its legs, *Hippobosca* often runs sideways like a crab. The flies of this genus, which infest horses and cattle, live chiefly between the thighs, along the perinæum, and under the tail. In India *Hippobosca francilloni*, Leach (*H. canina*, Rond.), which infests dogs, has been found to the number of fifty or a hundred on the necks and chests of pariahs.

PART II.

Directions for the Collection of Specimens.

List of Articles Required.

An entomologist's collecting-net.—This can be obtained from any dealer in natural-history apparatus. Any net used for collecting butterflies will do for Diptera; but, on the whole, perhaps an ordinary umbrella-net will be found the most serviceable. One or two spare net-bags should be taken in case the one in use gets torn.

Two dozen glass-bottomed *cardboard pill-boxes* (assorted sizes, up to 2¼ inches in diameter, packed in nests one inside another).*

One or two *cyanide killing-bottles*, not too large to be carried in the pocket when required; or a larger-sized cyanide killing-jar, or

* These boxes can be obtained from Messrs. Watkins & Doncaster, 36, Strand, London, W.C.; but care should be taken to see that the *bottoms*—and not the tops, as is often the case—are made of glass. Since the boxes are constructed of cardboard, they are liable in tropical countries to go to pieces in the rains; and to prevent this they should be covered with jaconet in the following manner, the important point to remember being that the jaconet must be cut in strips *on the cross*:—Obtain, say, a square yard of the material, and fold it into a triangle by bringing two opposite corners together. Consider how wide the strips must be, according to the varying depths of the boxes to be covered, and rule them off in pencil by drawing lines *parallel to the base* of the triangle. Cut up the strips, or if possible get them cut by a bookbinder's machine. Paint the box over with liquid glue, and wrap the jaconet round it: it is particularly important that the edges of the glass and lid should be well protected; and it will be found that by gently pulling the jaconet it will wrap itself round these without difficulty. When quite dry, say the following day, the box should be given a coat of Aspinall's enamel, or of paint, a second (and if necessary a third) coat of paint being added after the first is dry. Any paint or glue on the glass can be removed with a penknife; if the jaconet protrudes too far over the glass, cut it round with a penknife and remove it. (Glass-bottomed boxes already protected in this manner can be obtained from Miss E. M. Bowdler Sharpe, 4, Barrowgate Road, Chiswick, London, W.)

A simpler method of protecting the boxes is to coat them (especially the joints) with shellac dissolved in absolute alcohol.

Glass-bottomed boxes of this kind constructed of tin are sometimes sold; but these are not to be recommended, since when in use in warm climates they are apt to become very hot, with the result that flies contained in them are killed and become dry prematurely.

materials for making same, as follows: ¼ lb. of cyanide of potassium,* 1 lb. of plaster of Paris, a glass jar with wide mouth and closely fitting lid.†

Fig. 12. Entomological Forceps.

Entomological forceps (two pairs), with curved ends for holding pins (from G. Buck, 242, Tottenham Court Road, London, W.).

Fine-pointed forceps (one or two pairs): these are useful for arranging the legs and wings of specimens when pinned; they can be obtained with the above.

* If it is intended to take cyanide to a damp tropical climate, it should be conveyed in the form of *lumps*, in a bottle with a tightly fitting glass stopper. Cyanide of potassium is also sold in rods, and, in this form, might be conveniently carried in short lengths in hermetically sealed tubes of thin glass, of diameter and length just sufficient to take the section of cyanide rod.

† Cyanide killing-bottles can be procured ready for use from Hinton & Co., Bedford Street, London, W.C., or any other chemist will prepare one to order; but when Diptera are collected in the manner advised below, it is preferable to use a large-sized killing-jar, which should be made as follows:—Take any fairly large glass jar (such as a pickle-bottle) with a wide mouth and closely fitting lid (a lever-lid such as those often fitted to pickle-bottles would answer admirably), and cover the bottom with a layer of dry plaster of Paris to the depth of ½ inch; pour in above this a layer equal in depth consisting of *powdered* cyanide of potassium, mixed with rather more than its bulk of dry plaster of Paris; cover this mixture with a layer of dry plaster of Paris to the depth of ¼ inch or so; and pour in above the whole a layer ½ inch in depth, consisting of plaster of Paris mixed with water to the consistency of cream. As soon as the top layer of plaster is dry the jar is ready for use: the plaster, however, should be covered with several thicknesses of blotting-paper, to avoid risk of injury to specimens in case the surface should at any time become wet. To obviate the danger of cracking the jar owing to the heat evolved when plaster of Paris is mixed with water, it may be advisable to stand the jar in warm water before adding the final layer. The exact amount of cyanide of potassium to be used is of no great consequence; but in the case of a properly prepared jar the odour should be readily perceptible on removing the lid: if it is not, the reason may be that the mixture is too dry, when a little water poured on to the top layer will probably set matters right. After some months' use the cyanide loses its efficacy (to obviate this so far as possible the jar should never be allowed to remain open), and the mixture must then be renewed.

A rough-and-ready method of making a killing-jar or bottle is to cover the bottom with a layer of powdered cyanide, and to place above this a number of layers of blotting-paper. The layers of blotting-paper immediately in contact with the cyanide must be slightly damped; but only sufficient water should be used to cause the cyanide to give off its odour. The top layer of blotting-paper must on no account be wet, and the less water used the better.

Needles (two or three) *mounted in handles*,—also for arranging legs and wings.

Entomological pins (D. F. Tayler & Co., New Hall Works, Birmingham), Nos. 5 (1*s.* 6*d.* per ounce), 7 (2*s.* 6*d.* per ounce), and 20 (7*s.* 6*d.* per ounce). The No. 20 pin should be used for all but the very largest Diptera, such as Horse-flies (Tabanidæ); as it is exceedingly fine, an ounce will go a very long way.

Common pins—a thousand or two, in paper packets.

Gun-wad punches, Nos. 4, 12, and 20 bores (from any gun-maker), for punching discs of card.

Cards (3-sheet Bristol board), from which to punch discs; a supply of the latter should be prepared ready for use.

A platyscopic lens (Messrs. Baker, 244, High Holborn, London, W.C.; or John Browning, 63, Strand, London, W.C.: price about 15*s.*). The magnifying-power should not be too high—from 10 to 15 diameters is about the best.

Cork-carpet or pith.—Two or three sheets about 6 inches square, on which to perform the operations of pinning, etc. (Cork-carpet can be obtained at Harrod's Stores, Brompton Road, London, S.W.)

Two or three cork-lined entomological store-boxes.—These can be obtained from Messrs. Watkins & Doncaster, or any other dealer in natural-history apparatus. For a collecting trip or expedition of some duration the boxes should not be smaller than about 18 inches by 12, and they must be sufficiently deep to prevent the heads of the pins from coming into contact when both sides of the box are filled. Should the collector run out of store-boxes, *cigar-boxes*, in the bottom of which is fixed a layer of cork-carpet or pith, make efficient substitutes; but if pith is used, it should not be less than ½ inch thick.

Alcohol, 90 per cent. (ordinary rectified spirit).

Perchloride of mercury, aqueous solution, 1 in 500.

Method of Collecting.

If possible, Diptera should always be brought home alive in the glass-bottomed pill-boxes (to which they are to be transferred on being captured in the net), and should then be killed in the cyanide-bottle or jar immediately before being pinned. As soon as a fly is taken in the net by a dexterous sweep, a sharp turn of the wrist must be given (following a smart downward or lateral stroke in order to bring the fly to the end of the net), in such a way that the end of the net containing the insect falls over the rim and so makes a closed bag from which it cannot escape. The end of the net can then be gathered up in the hand, and the fly forced into a still smaller space, in which it will not be difficult to get it into a pill-box,

and then to slip on the lid. If the specimens are small, it is possible with care to get several into one pill-box. Flies may also be transferred direct from the net to the killing-bottle, and so brought home dead; but this method is not to be recommended, since prolonged exposure to the effects of cyanide of potassium is apt to injure the specimens, the ultimate condition of which, when so treated, is rarely as satisfactory as if they had been brought home alive in pill-boxes. If, however, it is necessary for any reason to dispense with pill-boxes, and to use the killing-bottle in the open, a little crumpled tissue-paper should be placed inside it; this affords a lodgment for the specimens, and so lessens the risk of their being injured by rolling about. It is always advisable when out collecting to carry a killing-bottle for use in case of need, in the event of the supply of pill-boxes running short. Diptera on windows may be captured in pill-boxes; if the edge of the box is slightly raised from the glass on one side, and a little tobacco smoke blown into it so as temporarily to stupefy the fly, it will be found easy to slip on the lid without allowing the insect to escape.

Killing.

Diptera brought back alive after a day's collecting should be killed by being placed for a few minutes in the closed cyanide-bottle or jar. If the cyanide-jar is sufficiently large, the pill-boxes themselves may be placed therein, first opening them a fraction of an inch on one side to allow the cyanide to take effect. In the case of large sluggish Diptera, such as *Tabanus*, the pill-box may be opened without fear of the insect effecting its escape; after which a smart tap on the bottom of the box will cause the fly to drop into the jar. Diptera should never be allowed to remain exposed to the effects of the cyanide longer than is necessary to ensure their being quite dead. If the poison is of reasonable strength, four or five minutes should be sufficient to kill even the largest and strongest flies; on the other hand, it is necessary to make sure that the insects are really dead, since, if the exposure to cyanide has been too short, flies will often appear to be dead when in reality they are only stupefied. As soon as the insects are really dead, they should be removed from the killing-jar; those in pill-boxes may be allowed to remain therein until one is ready to pin them, while the loose specimens should be turned out on to a sheet of cork-carpet or pith.

Methods of preserving Diptera other than by pinning.

Diptera should always be pinned, and this should be done as soon as they are dead. If preserved in any other way, they will never make such satisfactory specimens.

When, however, it is impossible to pin them, Diptera may be preserved in fine sawdust, on which a few drops of dilute carbolic acid should be sprinkled to prevent mould. Each specimen, before being placed in the sawdust, should be loosely screwed up in fine tissue-paper (cigarette-paper would do), on which the necessary data (see below under "Pinning") should be written in pencil. To contain the specimens a small tin box (such as those in which tobacco is sold) should be used; and to prevent injury from shaking, the box should be packed *quite full* of sawdust and specimens.

Diptera may also be put away for transport in three-cornered envelopes of soft paper (newspaper), after the manner in which butterflies are packed by collectors; but this method does not suit thick-bodied flies, such as *Tabanidæ*, as these are often crushed by it, and if once flattened cannot be restored to their natural shape. Envelopes containing Diptera or other insects may be conveniently packed in tin tobacco- or biscuit-boxes for transmission by parcel-post from abroad. A few drops of weak carbolic acid should be sprinkled over each layer of envelopes, and the box should be packed quite full.

It is never advisable to put Diptera for transmission from abroad into small boxes containing wool, as when flies are once in contact with wool, and have become dry, it is very difficult to remove them without pulling off legs, bristles, etc.

Pinning.

Take a card disc, and write on it all the data connected with the specimen to be pinned, as follows: (1) name of *locality*, including altitude if necessary; (2) *date*—day, month, year—thus, 6. 3. 04; (3) *collector's name*; (4) any *brief remarks of interest* (which may if necessary be written on the other side)—*e.g.* "Very common"; "Only specimen seen"; "On porter's back"; "At watering-place in stream"; "Running on banana leaves." Longer notes on habits, etc., should be entered in a note-book, with a number corresponding to one written on the disc. Specimens taken *in coitû*, for which a good look-out should always be kept when collecting, should have the fact noted on the disc of each, thus: "A—*in coitû* with B"; "B—*in coitû* with A."

Place the disc on which the above particulars have been written, plain side uppermost, on a sheet of cork-carpet or pith, and, picking up with the forceps an entomological pin (a No. 20 if the specimen is not larger than a Blue-bottle, otherwise a No. 7 or No. 5), thrust it through the centre of the thorax of the specimen, until about $\frac{1}{3}$ inch protrudes beneath. Next grasp the pin with the forceps near the tip, and thrust it through the disc, drawing it well down. Lastly, thrust an ordinary pin through the disc near the

margin for the purpose of carrying both disc and specimen, and draw the disc a good half-way up the carrying-pin.

The last thing to be done is to arrange the legs and wings as far as possible. The wings must be made to project at an angle from the body, and not allowed to lie closed over it; if they can be got to remain at right angles to the body, so much the better. In the case of any specimen that is not too small and fragile, the wings can be best arranged by means of the fine-pointed forceps, by making a gentle simultaneous pressure with the tips of the forceps at the base of each wing, repeating it until the wings assume the desired position. The legs also must be disposed symmetrically (and as far as possible in a natural position) on the card disc, so that all parts of them can be readily seen, and must not be allowed to remain crumpled up beneath the body, since important characters are often found upon them. In the case of a fairly large specimen it will generally be found possible to cause the legs to remain in the desired position by hooking the claws on the edge of the disc, gently drawing the legs out one after another by aid of a needle or one leg of the fine-pointed forceps. The manipulations in connection with the legs and wings must be performed as gently as possible, and care must be taken that bristles, hairs, or scales are not rubbed off in the process. As soon as these operations are completed, the specimen should be transferred to a store box, or to one lined with cork-carpet or pith, as described above. Since, however, the tissues contract in dying, the legs and wings are very apt to get pulled out of place, and, to correct these changes, the specimens should be examined once or twice during the next day or two after being pinned.

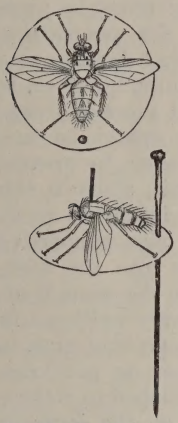

Fig. 13.—Use of Discs.

Very minute or fragile specimens (such as *Ceratopogon* or *Simulium*) are best *pinned from the side*, and the legs should then be straightened out by means of a No. 20 pin held in the entomological forceps.

Diptera collected in the Tropics: Attacks by Ants—Mould—Transmission to England.

In the tropics boxes of pinned insects are very liable to the attacks of minute *ants*, which, if they once gain access to a box unobserved, will soon play havoc with its contents. In Brazil it has been found that ants can be prevented from entering insect-boxes by smearing the outside round the line where the box opens, or any other possible place of entrance, with *andiroba* oil, repeating the process as often

as necessary; similar methods might be employed elsewhere in case of need.

Mould, however, is an even greater enemy to collections of Diptera. Pinned specimens of Diptera, like those of other insects, rapidly develop mould during the rainy season in tropical countries; and since mouldy specimens are practically worthless for purposes of scientific determination, *Diptera should always be sent home as soon as possible after being collected.* The risk of mould may, however, be diminished by pinning in a corner of the box a small piece of sponge saturated with the strongest carbolic acid, which should be constantly renewed. The greatest care must be taken to prevent specimens getting loose and rolling about in transit, since in this way a single loose disc might easily do irreparable injury to many other specimens in the box. To prevent this the pins supporting the discs should be inserted as tightly as possible into the cork-carpet or pith, and they should all be driven in to the same level, after which a sheet of soft paper (newspaper does very well) can be *fixed* into the box, resting on the heads of the supporting pins, in order to minimize the damage should a disc happen to get loose. The box containing the specimens should be well wrapped in cotton-wool or similar material, to secure it from shocks on the journey, and firmly *packed in an outer case* for transmission (by parcel-post if possible and the package is not too large) to England.

Number of Specimens of each Species required.

At least half a dozen specimens of *each sex* of a species should, if possible, always be obtained, and a good look-out should be kept for specimens showing any abnormality in structure, coloration, or size. When the collector remains long enough in one spot, he should always endeavour to obtain specimens of a species on different dates, in such a way as to throw as much light as possible on the duration of its seasonal occurrence. Similarly the attempt should be made to illustrate the geographical range or local distribution of a species, by collecting specimens in as many different localities as possible. Specimens of species taken in new localities, though common elsewhere, will always be valuable.

In addition to Pinned Specimens, others should be Preserved in Alcohol.

Pinned specimens should always, if possible, be accompanied by others preserved in alcohol. The following directions have kindly been supplied by Lieut.-Colonel G. M. Giles, who has found that the method indicated answers well in practice,—"Flies intended for anatomical examination must be fixed by heat, since their chitinous

envelope is penetrated so slowly by alcohol that, if this be not done, they decompose before the preservative can reach them. It is sufficient to bring them to boiling temperature in a test-tube of water, but for delicate histological work it is better to boil in a mixture of equal parts of 90 per cent. alcohol (ordinary rectified spirit) and aqueous solution of perchloride of mercury, 1 in 500. Even protozoal parasites are well preserved by this method. When fixed, preserve in 90 per cent. alcohol. *Methylated spirit* should *not* be used, since its acidity and other impurities may lead to embarrassment in the use of aniline stains." The specimens should be preserved in small glass tubes, with a plug of soft paper placed inside on the top of the specimens to prevent them from being injured by washing about in transit. A slip of paper, on which all necessary data should be written clearly *in pencil*, should be placed *inside* each tube, and the pinned specimens of the same species should be labelled with a reference to those in spirit, so that the latter may be identified. The tubes containing the specimens should preferably be placed for transmission inside a larger bottle of spirit; if this be done, it is only necessary to secure the mouth of each tube by tying muslin over it. Cotton-wool, or, better still, horse-hair or shavings, should be inserted as packing between and especially on the top of the tubes.

Larvæ.

Specimens of larvæ will always be valuable, whenever it is possible to breed out some of them so as to determine the fly to which they belong. Unless, however, the perfect insect is known, it is rarely possible to do more than to determine the *family* or *genus* to which a larva belongs. Larvæ for preservation should be killed by immersion for *a moment or two* in boiling water, and should then be placed in weak spirit (two-thirds spirit and one-third water); after being allowed to remain in this for two or three weeks until thoroughly hardened, they can be transferred to stronger spirit. The larvæ of each species must of course be kept separate, and should be put up in a small corked glass-tube full of spirit, the necessary particulars, with, if possible, a reference to pinned specimens of the perfect insect, being written in pencil on a scrap of paper and placed *inside*.

Notes on Habits, etc.

Comparatively little is yet known as to the bionomics of Blood-sucking Diptera in general, so that notes on the habits, distribution, seasonal occurrence, relative frequency, etc., of particular species will always be of great value and interest. Clinical observations as to the effect of the bites of the various species on man and domestic animals are also required.

PART III.

Fleas, Bugs, and Ticks.

Fleas, bugs, and ticks are wanted in addition to Blood-sucking Diptera. These creatures, however, must not be pinned, but should be preserved and sent home in alcohol, by the same method as that recommended for Diptera (see pages 20, 21). To contain the specimens it is best to use small corked glass tubes, which should be carefully packed in cotton wool in a strong wooden or metal box for transmission to England. A plug of soft paper should be placed on the top of the specimens in each tube, to prevent injury from shaking or washing about, and there should also be inserted in the tube a slip of paper bearing the necessary data written in pencil. Specimens of different species should of course be put up in separate tubes.

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